Renews River Salmonid Research Project: Year 1 (2007) Data and Results

G. Veinott

Science Branch
Department of Fisheries and Oceans
P.O. Box 5667
St. John's, NL
A1C 5X1

2009

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2894

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1-900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 901-1425 were issued as Manuscript Reports of the Fisheries Research Board of Canada. Numbers 1426-1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Manuscript Report of
Fisheries and Aquatic Sciences 2894

2009

RENEWS RIVER SALMONID RESEARCH PROJECT: YEAR 1 (2007) DATA AND RESULTS

by

G. Veinott

Fisheries and Oceans Canada
Science Branch
P.O. Box 5667
St. John's, NL
A1C 5X1

© Her Majesty the Queen in Right of Canada, 2009.
Cat. No. Fs97-4/2894E ISSN 0706-6473
Cat. No. Fs97-4/2894E-PDF ISBN 1488-5387

Correct citation for this publication:

Veinott, G. 2009. Renews River Salmonid Research Project: Year 1 (2007) data and results. Can. Manuscr. Rep. Fish. Aquat. Sci. 2894: v + 30 p.

Table of Contents

Page

ABSTRACT/RÉSUMÉ IV

INTRODUCTION 1

METHODS 1
FISH SAMPLING 1
HABITAT TYPING 2
CREEL SURVEY 2
BIOLOGICAL CHARACTERISTICS 3
PREDATOR SURVEY 3
WATER CHEMISTRY 3
REDD SURVEY 4

RESULTS 4
ATLANTIC SALMON AND BROWN TROUT DISTRIBUTION AND ABUNDANCE 4
BIOLOGICAL CHARACTERISTICS 5
PREDATOR SURVEY 6
WATER QUALITY 7

DISCUSSION 7
SALMONID DISTRIBUTION AND ABUNDANCE 7
BIOLOGICAL CHARACTERISTICS 9
PREDATORS 10
WATER QUALITY 11
REDD SURVEY 12
FUTURE PLANS 12

ACKNOWLEDGMENTS 13

REFERENCES 13

ABSTRACT

Veinott, G. 2009. Renews River Salmonid Research Project: Year 1 (2007) data and results. Can. Manuscr. Rep. Fish. Aquat. Sci. 2894: v + 30 p.

This report provides an overview of the data collected in the first year (2007) of a planned six year study of salmonid populations in the Renews River watershed. The majority of fish collected in the main stem of the river were juvenile atlantic salmon but densities were considered low. The number of returning adult Atlantic salmon was estimated at 30 to 40 fish which would represent approximately 14% of the required spawning escapement. These low returns follow a trend that was reported provence wide in 2007. Brown trout numbers averaged less that two fish per electrofishing site. Nine brown trout were collected near the mouth of the river and no brown trout were sampled above Second Falls (river km 2.9). No fish sampled in the river exceeded 4+ years of age. Fluvial growth rates (1- 4 $cm*yr^{-1}$) and condition factors were the same for Atlantic salmon and brown trout. However, brown trout growth rates were significantly greater in the estuary (7-10 $cm*yr^{-1}$) compared to the river. All the major predators (terns, gulls, cormorants, and seals) had the opportunity to feed on salmon and trout at various life stages. Terns were likely restricted to feeding on parr sized fish whereas gulls and cormorants were more likely feeding on smolt sized fish. Seals were not present dring the smolt run but are capable of feeding on adult sized fish. Water quality was good with no indications of anthropogenetic pollution (e.g., sewage, household waste) entering the river. However, daily maximum water temperatures exceeded 22 °C 27 times which represents 48% of the available angling days sampled. Angling at such high water temeratures reduces the probability of survival for hooked and released fish. A redd survey suggested that very little spawning was occuring below Corner Pool.

RÉSUMÉ

Veinott, G. 2009. Renews River Salmonid Research Project: Year 1 (2007) data and results. Can. Manuscr. Rep. Fish. Aquat. Sci. 2894: v + 30 p.

Le présent rapport donne un aperçu des données recueillies en 2007, soit au cours de la première des six années prévues d'une étude des populations de salmonidés du bassin versant de la rivière Renews. La majorité des poissons prélevés dans le cours principal de la rivière était composée de saumons atlantiques juvéniles, mais leur densité était jugée basse. Le nombre de saumon atlantiques adultes revenus dans la rivière a été estimé à 30 à 40 poissons, ce qui représenterait environ 14 % de l'échappée de reproducteurs qui est nécessaire. Ces faibles montaisons suivent une tendance observée dans toute la province en 2007. Le nombre moyen de truites de mer a été inférieur à deux poissons par lieu de pêche électrique. Neuf truites de mer ont été prélevées près de l'embouchure de la rivière et aucune n'a été échantillonnée en amont des chutes Second (à 2,9 km de distance de pénétration de la rivière). Aucun des poissons échantillonnés dans la rivière n'avait un âge supérieur à 4 + ans. Les taux de croissance en rivière (1- 4 $cm*an^{-1}$) et les facteurs de condition étaient les mêmes pour le saumon atlantique et pour la truite de mer. Toutefois, le taux de croissance de la truite de mer dans l'estuaire (7-10 $cm*an^{-1}$) était très supérieur au taux de croissance en rivière. Tous les principaux prédateurs (sternes, goélands, cormorans et phoques)

pouvaient trouver à se nourrir parmi les saumons et truites des divers stades biologiques. Les sternes devaient vraisemblablement se limiter aux poissons de la taille d'un tacon, tandis que les goélands et les cormorans se nourrissaient plus probablement d'individus de la taille d'un saumoneau. Les phoques n'étaient pas présents pendant la montaison des saumoneaux, mais ils sont capables de se nourrir de poissons adultes. La qualité de l'eau était bonne et il n'y avait pas de signe de pénétration de pollution anthropique (p. ex., eaux usées ou ordures ménagères) dans la rivière. Toutefois, les températures quotidiennes maximales de l'eau ont été supérieures à 22 °C à 27 reprises, soit pendant 48 % des jours de pêche récréative ayant fait l'objet d'un échantillonnage. La propabilité de survie des poissons capturés et remis à l'eau par les pêcheurs à la ligne diminue quand la température de l'eau est aussi haute. Un dénombrement des nids porte à croire qu'il y a eu très peu de fraye en aval de la fosse Corner.

INTRODUCTION

Renews River is on the east coast of the Avalon Peninsula on the island of Newfoundland, Canada (See Fig. 1). It is a scheduled Atlantic salmon (*Salmo salar*) river and supports a brown trout (*Salmo trutta*) population of unknown numbers. There is a recreational brown trout fishery primarily at the mouth of the river in the estuary. Concerns raised by the Renews River Conservation Association (RRCA), a local stewardship group, prompted the Department of Fisheries and Oceans (DFO) to initiate a study focused on the brown trout population in the river and the estuary. The RRCA felt that the Atlantic salmon and brown trout populations were in decline. They were also concerned that these declines may be linked to dramatic changes in the marine ecosystem that local residents had witnessed over their lifetimes. For example, herring would "fill the bay" and the water would be "white with spawn", cod were plentiful as were American eel. All these species appear to have disappeared or declined. In contrast, concerns were raised that populations of cormorants and harbour seals were increasing and these piscivorous animals might be damaging the salmon and trout populations or inhibiting their recovery.

In response to these concerns DFO initiated the Renews River Brown Trout Study. During public consultations 6 main objectives were for the study were discussed. They included:

1. Study the distribution of Atlantic salmon and brown trout in the Renews River watershed;
2. Examine the biological and growth characteristics of the *Salmo* species in the watershed;
3. Determine the habitat preferences of the *Salmo* species in the watershed;
4. Determine the degree of anadromy of the brown trout population;
5. Estimate the population of brown trout in the estuary and in the freshwater portion of the system; and
6. Observe and record the occurrence of seals in the estuary.

The report outlines the work carried out and the data collected during the first year (2007) of the proposed 6 year study. Some of the original objectives were modified or deferred to other years. For example, in the first year the distribution of salmon and trout was confined to the main stem of the river down stream of Corner Pool. Study of anadromy was deferred and observations on the occurrence of seals in the estuary were expanded to include major potential predators of salmon and trout.

METHODS

FISH SAMPLING

Sampling of the fish population was carried out at 8 locations (Fig. 1) down stream of Corner Pool on Renews River in September, 2007. A Smith Root LR24 backpack electrofisher was used to briefly immobilize fish that were then collected by dip net. At each new site the electrofisher's Quick Setup feature was used to initialize instrument settings. Voltage, frequency, and duty cycle were then adjusted manually; according the instrument's operating instructions, to settings that caused fish to be drawn to the

anode. Typical settings for Renews River were 750 volts, frequency of 40 Hz, and a 15% duty cycle. At Site 100A barrier nets were used to block the river and two electrofishing passes were made. At Site 700 a second electrofishing pass was made without barrier nets. The data from Sites 100A and 700 were used to estimate the population in those reaches using the equation of Zippen (1958).

HABITAT TYPING

With the exception of Site 100A, which was used to estimate salmonid population and was not one of the standard sampling sites, measurements of the wetted width, water depth, and water velocity were taken at each electrofishing site. The wetted width is the perpendicular distance across a stream that is under water (Scruton et al. 1992). Measurements of wetted width, to the nearest 0.1 m, were taken at the start and end of each site. Water depth, to the nearest millimetre, and water velocity were taken three to 5 times at equal intervals across the stream at the start, middle and end of the section. The exception was Site 600 where water depth and velocity were low, therefore, only four sets of measurements were taken, mid stream, along the length of the section. Water velocity measurements at all sites were taken at approximately ½ the total depth using a Gurley pygmy current meter model 625D attached to a Gurley model 1100 flow velocity indicator. Estimates of the percent of each substrate type (sand, gravel, cobble, etc.) present in the section were also recorded following the method in Scruton et al. (1992).

CREEL SURVEY

A roving creel survey with non-uniform probability sampling (Malvestuto et al. 1978) was initiated to estimate effort and catch in the recreational Atlantic salmon fishery. Briefly, Renews River was divided into two fishing areas: First Falls and the mouth; Second Falls and Corner Pool (See Fig. 1). Each day of the fishing season was divided into three sampling units: AM, 0700 h-1100 h; Noon, 1100 h-1500 h; and PM, 1500 h-1900 h. The area, day, and sampling unit when a survey was to be conducted, were randomly selected with a higher probability of weekend days and AM and PM units being selected. This assumes more angling was likely to occur on weekends and in the mornings and evenings. Encountered anglers were asked the number of hours fished, expected total hours they would fish, number of fish caught, number released and number retained. However, the number of anglers encountered and total reported catch during the 2007 angling season was so low that the survey lacked acceptable statistical power. Therefore, reported effort was converted to "rod days" where 1 rod day is any amount of effort by an angler in one day (Ash and O'Connell 1985). A simple liner extrapolation was used to convert surveyed effort and catch to total effort and catch based on a 99 day angling season (Eqs. 1 and 2).

Eq 1. Daily effort = Rod Days/ Days surveyed
Eq 2. Total effort = Daily effort * 99

Total catch, (substituting catch for effort and Rod Days) was calculated in the same manner. Catch and effort was then compared with historical guardian surveys and Licence Stub Return (O'Connell et al. 1998) data for Renews River (Table 1).

Data were also collected, opportunistically, from the recreational brown trout fishery which takes place almost exclusively in the inner estuary. Anglers were asked the same questions as in the Atlantic salmon fishery and measurements were taken on any fish available. Since the data collection in the trout fishery did not follow a formal survey protocol only biological characteristics of the trout are presented in the results. A formal survey of the recreational trout fishery is planned for 2008 and 2009.

BIOLOGICAL CHARACTERISTICS

When possible, the fork length (FL), whole weight (WW) and a scale sample was taken for fish collected either as part of a deliberate sampling effort (i.e., electrofishing) or during the creel survey (fork length and a scale sample only). Fork lengths were taken using a measuring board and recorded to the nearest mm. Whole weights were taken on a portable electronic balance and recorded to the nearest 0.1 g. Scale samples were taken from a standardized location on the fish (above the lateral line and posterior of the dorsal fin). Scales were cleaned and aged according to the techniques outlined in ICES (1984) for Atlantic salmon or Elliott and Chambers (1996) for brown trout. For each species in freshwater the Fulton condition factor (Ricker 1975) was also calculated using the formula: $K=W/L^3$ where K is the Fulton condition factor; W is the weight of the fish in grams; and L is the fork length of the fish in cm.

Often during the creel surveys of the brown trout fishery it was possible to obtain the head and guts of retained fish. In these cases the otoliths were removed and a sex determination attempted.

PREDATOR SURVEY

Observations on presence and numbers of potential salmonid predators were carried out from June 21 to November 16, 2007. The Renews River estuary was divided into 3 observation areas: the mouth of the river; the inner estuary; and the main bay (Fig. 1.). Day, and time of day, was randomly selected for 30 minute predator surveys. During the 30 minutes an observer would scan each of the observation areas, using binoculars, for 10 minutes and identify and count potential salmonid predators. Logs were kept of the species observed, their numbers, observation conditions based primarily on weather conditions as (very good, good, fair, poor), as well as a reliability rating for the species. The reliability rating was logged as a percentage where 100% was a positive identification and 50% indicated a lack of confidence on the identification.

WATER CHEMISTRY

To test for the presence of anthropogenic pollution, analyses of Renews River water was carried out monthly in July, August and September, 2007. Three stations (mouth of

the river, below First Falls, and below Second Falls) were sampled and analyzed for phosphate, potassium, nitrate, and sulphate. Two additional sampling stations were added in August, one above Second Falls, and Little Butterpot Pond which is upstream of Corner Pool and is not shown in Fig. 1. Alkalinity, and hardness as total Ca and Mg, was added to the analyte list in September. All measurements were taken in the field with a portable LaMotte Smart 2 colorimeter using LaMotte reagents.

Three temperature loggers (Vemco Minilogger TX) were installed in Renews River on July 12, 2007. One was installed near the mouth of the river, one below First Falls, and the third below Second Falls. Water temperatures were measured and stored each hour until the loggers were removed on November 23, 2007.

To understand the degree of mixing of fresh and salt water that was occurring at the mouth of the river; salinity, pH, and temperature measurements were taken at high tide on the 30th of August, 2007. All measurements were taken using an YSI Incorporated 600QS sonde attached to a YSI 650 Multiparameter Display System

REDD SURVEY

On November 01, 2007 crews of two individuals walked assigned sections of Renews River covering the river from the mouth to just above Second Falls. Gravel areas deemed suitable for spawning were inspected visually for evidence of redds. On November 06, 2007 a crew of two individuals began at Corner Pool and worked their way downstream to just above Second Falls searching for redds.

RESULTS

ATLANTIC SALMON AND BROWN TROUT DISTRIBUTION AND ABUNDANCE

From Second Falls downstream only juvenile Atlantic salmon and brown trout were captured by electrofishing. Atlantic salmon juveniles were found at each site but brown trout were found only in the most down stream sites and between First Falls and Second Falls (Fig. 2). At sites where brown trout were captured, Atlantic salmon outnumbered brown trout by an average of 7:1. The highest abundance of brown trout was found near the mouth of the river and no brown trout were found above Second Falls.

At Site 600, below Second Falls, more than half (23) of the fish captured were fry. This site was hydrologically different from the other sites in that the habitat was classified as a flat because of the lower flow velocity and composition of the substrate (Scruton et al. 1992). All other sites were considered riffles (Table 2). The substrate at Site 600 was composed of mostly gravel, rubble, and cobble with fewer large and small boulders. The fry were not identified at the species level.

At Site 100A, 19 and 9 salmon parr were captured during the first and second electrofishing passes respectively. Site 100A was sampled on September 7, 2007 and was intended as a test site for the electrofishing. Therefore, no measures of the physical

characteristics of the site were taken. Nevertheless the population estimate for the site was calculated to be 36. In 2008 the area of the site was estimated at approximately 150 m^2 for a population density of 24 fish per 100 m^2. Site 700 was sampled on September 19, 2007 during 2 days of electrofishing when all other sites were electrofished and physical parameter data collected. The number of fish collected in two electrofishing passes was 17 and 14. The population estimate for this section of the river was 96 or 35 fish per 100 m^2.

The low number of anglers encountered in the creel survey and their poor success rate suggests that the number of adult Atlantic salmon returning to Renews River in 2007 was low compared to past runs. Only 23 different anglers (23 rod days) were encountered during 35 survey days with a catch of only 2 fish. No anglers reported releasing any fish. Using equations 1 and 2 above, total catch and effort for the season is estimated at only 6 fish in 73 rod days. This is in good agreement with the Licence Stub program which estimated the total catch and effort on Renews River at 6 fish and 80 rod days (Table 1). Total catches below 20 fish have been estimated for Renews River in past years using guardian data and the Licence Stub returns (Table 1), but 2007 would be the lowest catch per rod day on record.

Reddin (2009) (2008 Salmon RAP) estimated a retention fishery exploitation rate of 8-12%, on average, for Newfoundland and Labrador Atlantic salmon runs. This was based on angling data obtained from the Licence Stub program and adult returns at salmon enumeration facilities in Newfoundland and Labrador. The 8-12% is likely to be somewhat conservative as catch and release losses were not included in the analysis. However, even with a higher than average exploitation rate of 15%, the total Atlantic salmon run on Renews River for 2007 would only be estimated at between 30 and 40 fish based on the angling estimates from the license stub program and the creel survey respectively.

BIOLOGICAL CHARACTERISTICS

Fluvial Samples

The juvenile salmon and trout sampled in the river by electrofishing produced overlapping length-weight curves (Fig. 3). However, the low sample size of brown trout makes it difficult to conclude with any confidence that the similarities between the two samples are real. Nevertheless, when t-tests were used to compare the length at age 1+ and 2+ there was no significant difference ($p>0.05$) in length between the two groups (Fig. 4). There was also no significant difference between Fulton condition factors (K) in the two groups (t-test $p>0.05$). The modal age of the two groups was 2+.

Because there was no significant difference in the average age or condition of the salmon and trout in the river, the two species were grouped to compare growth rate. A fitted von Bertalanffy growth model (Fig. 5) suggests that the maximum size salmonids can reach in the river is 16 cm with growth rates of only 1-4 cm per year. The von Bertalanffy model can not accommodate ages of 0+, therefore, for calculating expected growth all ages were adjusted such that 0+ became 1, 1+ became 2, etc.

Estuarine Samples

The recreational fishery, carried out in the estuary, targets primarily brown trout. Little to no effort is put into angling Atlantic salmon in the estuary. Therefore, no salmon anglers were encountered in the estuary during the surveys so all samples collected in the estuary were brown trout. As well, no weights were collected during the recreational survey so only lengths and ages can be compared with the fluvial samples.

The length of trout taken in the recreational fishery ranged from 6.5 to 65 cm. The modal length category was 30-35 cm (Fig. 6) and the modal age was 3+ years (Fig. 7). Twenty-two fish were sexed and the male to female ratio was 1:1. There was no significant difference in the average length of males and females (t-test: $p>0.05$). A fitted von Bertalanffy growth model (Fig. 8) suggests that the estuarine brown trout in Renews reach a maximum length of about 60 cm with steady growth of 7-10 cm per year for the first 4 years then slower increases in length of 2-5 cm for the next 5 years.

Only 12% of the scales (n=66) from the brown trout fishery exhibited spawning marks. Three plus was the most frequent age of first spawning and 2+ was the most frequent river age (74%). Two scales had multiple spawning marks and one fish did not spawn for the first time until it was 5+ years old.

PREDATOR SURVEY

A list of all potential salmonid predators observed during the surveys is given in Table 3. Where possible animals were identified to the species level, however, not all gulls were identified to this level. The two most common species of gulls, positively identified, were herring gulls *(Larus argentatus)* and great black backed gulls (*Larus marinus*). The seals that were observed were identified as harbour seals (*Phoca vitulina*) but grey seals (*Halichoerus grypus*) can move near shore this time of the year as well. However, no grey seals were positively identified.

The 4 most commonly observed groups of predators were the common tern (*Sterna hirundo*), the double-crested cormorant (*Phalacrocorax auritus*), gulls, and harbour seals. For these groups, plots of the date observed verses number observed was produced (Fig. 9) with observations broken down into three areas: the mouth of the river, the inner estuary, and the main bay.

All but seals were present in the study area when observations began. Terns and cormorants are migratory and arrived prior to the start of the study. Seals were first observed in mid August in the inner estuary and the main bay (Fig. 9A and 9E) and were still present at the end of the field season (mid November). However, seals were most often observed in the main bay. No seals were observed in the mouth of the river. Terns were most abundant in the inner estuary where there is a nesting colony. Terns were last observed in the area in mid September (Fig. 9D). Cormorants were most abundant in the main bay and were last observed in the area in mid October (Fig. 9B and 9F). Therefore, there was overlap of the main potential salmonid predators during the months of June, July, and August.

WATER QUALITY

There were no obvious trends in the water chemistry data, either monthly or as sampling progressed upstream (Fig. 10). Little Butterpot pond had a somewhat higher alkalinity (8 ppm as $CaCO_3$), compared to an average of 3 ppm for the fluvial samples. However, even an alkalinity of 8 ppm would be considered low, and given the low hardness values (range 0-4 ppm Ca and Mg) the river has little buffering capacity. The river would be expected to experience sudden drops in pH should it be exposed to an acid event such as an increase in the acidity of the local precipitation or a spike in acid runoff during the spring melt.

The other parameters (potassium, sulphate, and phosphate) are well below any concentration that would be of concern (Global Environmental Monitoring System 2003, Government of British Columbia 2000, Canadian Council of Ministers of the Environment 2004). Nitrate concentrations of 3-8 ppm would be higher than most systems in Newfoundland (Dawe 2003) but still well below values considered harmful to aquatic life (Canadian Council of Ministers of the Environment 2003).

Temperature profiles obtained from the three sampling sites were nearly identical (Fig. 11) with individual hourly temperature variations among sites of less than 0.5 °C. The daily minimum-maximum range reached 10 °C on several occasions and many daily highs exceeded 25 °C. It should be noted that the loggers were placed in sheltered locations downstream of large boulders to protect them from being washed out during storm events. This may explain some of the high daytime temperatures.

The water at the mouth of the river would be considered brackish with salinity gradients seaward and with depth (Table 4). Temperature and pH decreased with depth and there was a logarithmic relationship between pH and salinity, with pH increasing with increasing salinity. The pH of the river water above head of tide ranged between 6.5 and 7.0.

REDD SURVEY

There was little evidence of spawning activity in the main stem of the river in the fall of 2007. Two redds were positively identified below First Falls and as well as evidence of test redds. Two possible redds were also identified at Corner Pool.

DISCUSSION

SALMONID DISTRIBUTION AND ABUNDANCE

In the first year of the study, directed sampling, focused on the main stem of the river from Corner Pool to the mouth of the river (Fig. 1). This stretch of Renews River has two natural barriers to fish migration: First Falls and Second Falls. Although the falls are not large enough to stop migrating adult Atlantic salmon it was felt that they may restrict the movement of brown trout up-stream. Therefore, a simple hypothesis that could have been tested was whether the number of brown trout declined as sampling progressed

up-stream. Although the highest numbers of brown trout were captured down-stream of First Falls (Fig. 2), the total number of brown trout captured by electrofishing was so low that it was not possible to statistically test, with any power, the proposed hypothesis.

The sampled habitat was certainly suitable for brown trout. The habitat type, average depth and velocity listed in Table 2 are similar to known brown trout habitat on the Avalon Peninsula (Gibson and Cunjak 1986) as well as general habitat criteria for salmonids in Newfoundland (Scruton et al. 2000). The low number of brown trout captured, then, suggests that the density and total population of brown trout juveniles in the main stem of the river is low. It is possible that the time of the year had an impact on the success of sampling trout in the river. The September electrofishing dates were late in the summer and water levels were low. The trout may have moved out of the main stem of the river to find cooler or deeper waters. Spring sampling was planned for 2008 to test this hypothesis and will be reported on in a future manuscript.

Juvenile Atlantic salmon were more abundant than brown trout. Although a detailed quantitative assessment of the juvenile salmon population was not done, the two sections that were electrofished twice give some indication of the expected population and hence density. At site 700 the estimated population was 96 for a density estimate of 35 fish per 100 m^2. At site 100A the population estimate was 36 fish, for a density of 24 fish per 100 m^2. Given the similarity in physical characteristics and catches at all sites it is likely a reasonable assumption that densities were similar for all site.

The densities found in Renews River are lower than those found in riffles in Northeast Brook, Trepassey (range 49-129 • 100 m^{-2}) in the 1980's and 90's (Mitchell et al. 2005). Renews River is only about 60 km from Trepassey, and both systems have similar physical and chemical characteristics (compare with Mitchell et al. 2005). Juvenile salmon densities, then, would be expected to be similar. However, Riley et al. (1993) reported a negative bias of up to 25% on population estimates using removal methods. As well, Scruton and Gibson (1995) suggested that catches of a minimum of 30 fish were required for quantitative electrofishing. Therefore, the Renews River density estimates are likely to have significant error values associated with them, and further quantitative sampling is required to more accurately assess the population density of juvenile Atlantic salmon in the system.

Results from the creel survey and the 2007 license stub program suggest that the returns of adult Atlantic salmon to Renews River were very low. Possibly as low as 40 adult fish. 2007 was a poor year for adult Atlantic salmon returns for all of insular Newfoundland (DFO 2008). For example Northeast Brook, Trepassey had a total return of 40 adults. Although 2007 was not the lowest total catch on record for Renews River (Table 1), such a low return is concerning for future juvenile densities in a river that may already have a small population of fish.

A survey of Renews River done in 1977 (DFO unpublished data; Renews River File) estimated that there were 2,047 fluvial salmon rearing units and greater that 113 h of lacustrine habitat in the watershed. DFO assesses the sustainability of Atlantic salmon populations by calculating the % conservation met. Where, 100% conservation is met when there are 240 salmon eggs deposited per fluvial rearing unit and 368 eggs per hectare of lacustrine habitat. Fecundity varies annually and among rivers in

Newfoundland and Labrador but averages around 3100 eggs per female for salmon under 63 cm (O'Connell et al. 2008). Assuming a population with 60% females, Renews River would require a minimum run size of 286 fish to attain conservation. With an adult run of 40 fish Renews River would have achieved only 14% conservation in 2007. Given the catch data in Table 1 it is unlikely Renews River reached conservation more than once in the past 5 years.

Similar estimates of the brown trout population could not be made owing to the small sample size. A more systematic sampling of the brown trout recreational anglers is planned for 2008. As well, a mark re-capture study is planned for 2008 to estimate trout populations in the estuary. However, conservation limits have not been set for brown trout.

BIOLOGICAL CHARACTERISTICS

Fluvial Samples

The data from the fish sampled in the river showed that salmon parr and juvenile brown trout were, on average, the same length, weight, and in the same condition (Fig. 3 and 4). Compared with Northeast Brook, Trepassey (Gibson 2002) the Renews River salmon parr are approximately 1 cm longer at age 1+ and over 2 cm longer by age 2+. This suggests that the Renews River salmon parr are growing at a faster rate than the Northeast Brook parr. However, Northeast Brook had the slowest growth of the 8 sites reported by Gibson (2002). The difference between Renews River and Northeast Brook is likely due to a more abundant food supply and lower densities in Renews River.

Estuarine Samples

The biological characteristics discussed here are based on the brown trout sampled in the recreational fishery. Although the salmon parr and juvenile brown trout grew at the same rate in the river, the same comparison can not be made with the estuarine sample since no salmon were sampled. However, the estuarine growth rate can be compared to the average fluvial growth rate. As expected the early growth in the estuary (7-10 cm/yr) was substantially faster than that recorded in the river (1-4 cm/yr). The estuarine growth rates are in good agreement with growth of anadromous brown trout in Placentia Bay and St. Mary's Bay, Newfoundland (O'Connell 1982 – his Figure 33). However, the maximum size of approximately 60 cm predicted here is somewhat lower than historic maximum size estimates from the Ewe River in Scotland (Butler and Walker 2004). The Ewe River experienced a collapse of their brown trout population. Maximum sizes between 1926 and 1993 were 70-80 cm. The most recent sample (1997-2001) had a maximum size estimate of only 45.6 cm (Butler and Walker 2004). Additional sampling of the Renews River brown trout fishery took place in 2008 but the data has not yet been processed. It will be interesting to see if there has been any decline in the estimated growth rates or maximum size.

Estuaries tend to be highly productive with the reward of rapid growth often balanced by the greater risk of predation. Estuarine residency by Atlantic salmon parr have been

reported in Newfoundland (Cunjak and Chadwick 1989), but similar reports on the downstream movement of brown trout parr in Newfoundland were not found. The modal age of the fish sampled in the recreational fishery was 3+, but 2+and 1+ fish were also caught. These fish could have moved into the estuary as smolt but it is also likely that there is a downstream migration of brown trout parr. Limburg et al. (2001) reported Baltic brown trout migrating to estuaries as fry. This behaviour was most common in short streams with spawning grounds close to the mouth. There was even evidence of coastal spawning in brackish waters. Similar behaviours could be occurring at Renews because there is very little suitable spawning habitat in the lower reach of the river and the natural barriers may be restricting movement upstream.

PREDATORS

The predator survey recorded the date and numbers of potential salmonid predators in the estuarine and the near marine environment around Renews River (Fig. 9). No attempt was made to quantify the numbers or species of prey taken by avian or mammalian predators. However, the opportunity for predation can be explored using the type of data collected in the predator survey (Cairns and Reddin 2000). As Cairns and Reddin (2000) point out, predation can only take place if the predator and prey are in the same location at the same time. As well the size of the prey must be within the size range that can be taken by the predator.

In 2007 the predator survey did not begin until June 21st. By that time all the most abundant predators (cormorants, terns, and gulls) with the exception of harbour seals were being observed in the area (Fig. 9). However, it is assumed that the smolt run was over by June 21. For example, the smolt run on Northeast Brook, Trepassey ended June 11, 2007. If the timing of the smolt run in Renews was similar, then most post-smolt would have been in the marine environment for 2 to 3 weeks by the time the predator survey began. If post smolts were still in the area they would be expected to be 13-15 cm long (Cairns and Reddin 2000). This is under the minimum prey size of 19 cm reported taken by herring and black backed gulls (see references in Cairns and Reddin, 2000 their Table 7). Minimum prey size occurs as a result of the energy density of the prey items. If the energy expended to capture and digest prey is greater than the energy obtained then it becomes unfeasible, from an energy budget perspective, to consume certain items

The 13-15 cm smolt size range is not outside the maximum prey size observed taken by common tern overwintering in Brazil (Bugoni and Vooren 2004), but it is outside the 5-9 cm range reported in the summer diet of common terns in the Northeast Atlantic (Granadeiro et al. 2002). In terms of prey size delivered to chicks, the 13-15 cm is likely too large. Burness et al. (1994) reported prey size delivered to tern chicks in proportion to the adult's bill size, where the range was 0.5 to 3 bill lengths. Give that an adult common turn's bill is approximately 3.5 to 4 cm long (Ahulu et al. 2006, Meissner and Krupa 2007) the maximum prey size (3 bill lengths X 4 cm) of 12 cm is slightly smaller than the smallest expected salmon smolt. Even if the tern colony was present at the start of the smolt run the average smolt size is still expected to be near 13 cm (Cairns and Reddin 2000) and would unlikely be a common food for terns in the area. However, it is likely that parr sized salmon and brown trout (5-9 cm) are abundant in the estuary.

Post-smolt size is not an issue for predation by cormorants or seals. During the smolt run on Maritime Province's rivers, salmon can make up 3.3% of the cormorant's diet (Cairns 1998). Further, during May on the Penobscot River in Maine, salmon smolts were frequently found in cormorant stomachs (Blackwell et al. 1997). May is when the smolt run at Northeast Brook Trepassey peaks. Unfortunately we do not have any observations for May. However, local residents have expressed concern that the cormorant population is expanding and that the birds are targeting the smolt run.

Prey size for double-crested cormorants in natural freshwater habitats ranged from 6 to 21 cm (Glahn et al. 1998; Hirsch 1986; Hobson et al. 1989; Campo et al. 1993). Adult salmon, although co-occurring with cormorants during the summer, are too large to be taken. As well, most of the brown trout in the estuary (Fig. 6) are outside this range. This provides a good example of how the rapid growth occurring in the estuary proves to be an advantage. In the estuary brown trout exceed the maximum cormorant prey size at age 3+ (Fig. 8). Whereas in the stream, fish are still vulnerable up to age 4+ (adj. age of 5+) (Fig. 5).

Harbour seals were not observed in the study area until early August (Fig. 9A) which would have been long after the smolt run. So unless the seals arrived during the smolt run then left the area to return at a later date, it would seem that harbour seals are not deliberating foraging on smolt near the mouth of the river. Of course salmon smolts eventually leave the harbour and the opportunity for predation by seals would exist as the smolt moved further from the study area.

Adult salmon and brown trout fit well into the average prey size of 5-55 cm reported for harbour seals (Bowen and Harrison 1996; Sjare et al. 2005). However, salmonid remains are rarely reported in the stomachs of harbour seals. In Newfoundland the more common prey items reported in harbour seal stomachs were flounder, cod, and sculpin (Sjare et al. 2005). Nevertheless, reports of seals attacking and eating salmon are common in Newfoundland (B. Sjare DFO, unpublished data), and Carter et al. (2001) reported observations of harbour seals eating large salmon in two Scottish estuaries. In the Carter et al. (2001) study, harbour seals were observed taking over 500 salmonids on the River Dee in 1995-96. However, it is not clear from Carter et al. (2001) how many individual seals were occupying the River Dee area during this time. The total population of harbour seals in Scotland in 1998 was estimated at 29,600 (Carter et al. (2001) which is large compared to the 5000-6000 estimated for Newfoundland (Hammill and Stenson 2000). And of the 9 sites reported on in Sjare et al. (2005) the maximum count in the Renews/Chance Cove area was 164. It is unlikely then that seals are a major threat to the sustainability of the adult salmonid populations in Renews harbour

WATER QUALITY

The chemical parameters; phosphate, nitrate, sulphate, and potassium were selected to test for evidence of anthropogenetic pollution entering the Renews River. Potential sources of these analytes are sewage, fertilizers, household wastes, animal waste, and/or industrial activity. However, the concentration of each analyte was well below

that which is recommended for the protection of aquatic life. For example the Government of British Columbia (2000) has set the protection of aquatic life guideline for sulphate at 50-100 ppm whereas the maximum measured in Renews River was 8 ppm. Nitrate concentrations were concerning because they exceeded those found in most water bodies tested in Newfoundland (Dawe 2003) however, the nitrate concentrations in Renews River are still well below 13 ppm which the Canadian Council of Ministers of the Environment (2003) set as the guideline value for the protection of aquatic life.

Alkalinity and hardness (Ca&Mg) are indicators of the acid buffering capacity of water and pH is a direct measure of the acidity. With alkalinity consistently below 10 ppm (200 μeq/L) Renews River would be considered poorly buffered and "highly sensitive" to acidification (Scruton 1986 his table 12). However, if Renews has an annual average pH of >5.4 there is no immediate threat to the salmon population (Watt 1981).

The temperature loggers produced remarkably similar thermal profiles for the three stations (Fig. 11). Having the loggers in sheltered areas downstream of large boulders probably produced water temperatures that were near the upper limit to which salmon and trout in the river would have been exposed. However, there are very few deepwater refuges in the main stem of the river and fish were often found under and around large boulders.

In terms of an acute effect (cessation of feeding or death) on juvenile Atlantic salmon, temperatures need to exceed approximately 22 °C (Elliott (1991). Brown trout may be a little more sensitive and cease feeding at approximately 19 °C (Elliott 1981). As well, the survival rate of hhoked and released fish decreases with increased temperatures (Dempson et al. 2001). Using the 22 °C (daily max.) value as a benchmark for increased stress then, would see Renews River trout and salmon under increased stress for 27 of the days for which temperature data were collected. In terms of the available salmon angling days that were captured by the loggers, water temperatures exceeded 22 °C 48% of the time.

REDD SURVEY

The redd survey produced very little evidence of spawning in the study area. This was somewhat expected as an earlier survey of Renews River (DFO unpublished data; Renews River River File) found only one section down stream of Corner Pool with suitable spawning habitat. However, brown trout may be able to take advantage of marginal spawning streams. Limberg et al. (2001) reported that Baltic brown trout may even spawn in brackish waters. Although spawning success would be compromised by such a strategy, it is worth investigating in Renews given the lack of evidence of juvenile brown trout populations upstream of Second Falls.

FUTURE PLANS

Plans are in place to re-sample the electrofishing sites earlier in the year to try to determine if the late sampling last year was a factor in the low numbers of trout

captured. A mark re-capture study is planned for the estuary. A trap will be used to capture and mark fish. Population estimates can be made based on the number of marked fish that are re-captured. Otoliths that have been collected will be analyzed to study movements between fresh and salt water. As well, otoliths will be used to determine whether trout caught in the recreational fishery are of Renews River origin. A more formal and detailed creel survey of the estuarine recreational fishery is planned. Finally, trout will be tagged with acoustic transmitters which will allow for the tracking of their movements into marine waters.

ACKNOWLEDGMENTS

This work was wholly funded by the Department of Fisheries and Oceans. Special thanks to Linda Reddy for her valuable field work. Thanks to Art Walsh and Vicki Morris for field assistance, Don Caines for aging scales, and Neila Cochrane for technical assistance. Thanks to Peter Downton and Peter Wesley for help with the redd survey.

REFERENCES

Ash, E.G.M., and O'Connell, M.F. 1985. Atlantic salmon fishery in Newfoundland and Labrador, commercial and recreational, 1985. Can. Data Rep. Fish. Aquat. Sci. 672: v + 284 p.

Ahulu, A.M., Nunoo, F.K.E., and Owusu, E.H. 2006. Food preferences of the common tern, *Sterna hirundo* (Linnaeus, 1758) at the Densu Floodplanes, Accra. West Afr. J. Appl. Ecol. 9: 1-7.

Blackwell, B.F., Krohn, W.B., Dube, N.R., and Godin, A.J. 1997. Spring prey use by double-crested cormorants on the Penobscot River, Maine, USA. Colon. Waterbirds. 20: 77-86.

Bowen W.D., and Harrison G.D. 1996. Comparison of harbour seal diets in two inshore habitats of Atlantic Canada. Can. J. Zool. 74:125–135

Bugoni, L., and Vooren, C.M. 2004. Feeding ecology of the Common Tern *Sterna hirundo* in a wintering area in southern Brazil. Ibis 146: 438-453.

Burness, G.P., Morris, R.D., and Bruce, J.P. 1994. Seasonal and annual variation in brood attendance, prey type deliverd to chicks, and foraging patterns of male Common Terns (*Sterna hirundo*). Can. J. Zool. 72: 1243-1251.

Butler, J.R.A., and Walker, A.F. 2004. Characteristics of the sea trout *Salmo trutta* (L.) stock collapse in the river ewe (Wester Ross, Scotland), in 1988-2001. *In* Sea trout: biology, conservation and management. Edited by G. Harris and N. Milner. Blackwell Publishing, Oxford. pp. 45-59.

Cairns, D.K. 1998. Diet of cormorants, mergansers and kingfishers in Northeastern North America. Can. Tech. Rep. Fish. Aquat. Sci. 2225: 32 p.

Cairns, D.K., and Reddin, D.G. 2000. The potential impact of seal and seabird predation on North American Atlantic salmon. DFO Can. Sci. Advis. Sec. Res. Doc. 2000/12.

Campo, J.J., Thompson, B.C., Barron, J.C., Telfair II, R.C., Durocher, P., and Gutreuter, S. 1993. Diet of double-crested cormorants wintering in Texas. J. Field Ornithol. 64: 135-144.

Canadian Council of Ministers of the Environment. 2003. Canadian water quality guidelines for the protection of aquatic life: Nitrate Ion. Ecosystem Health: Science-based Solutions Report No. 1-6. National Guidelines and Standards Office, Water Policy and Coordination Directorate, Environment Canada. 130 pp.

2004. Canadian Guidance Framework for the Management of Phosphorus in Freshwater Systems. Ecosystem Health: Science-based Solutions Report No. 1-8. National Guidelines and Standards Office, Water Policy and Coordination Directorate, Environment Canada. 114 pp

Carter, T.J., Pierce, G.J., Hislop, J.R.G., Houseman, J.A., and Boyle, P.R. 2001. Predation by seals on salmonids in two Scottish estuaries. Fish. Manag. Ecol. 8: 207-225.

Cunjak, R.A., and Chadwick, E.M.P. 1989. Downstream movements and estuarine residence by Atlantic salmon parr (*Salmo salar*). Can. J. Fish. Aquat. Sci. 46: 1466-1471.

Dawe, P. 2003. Water quality trends in selected water bodies of Newfoundland and Labrador. Water Resources Management Division, Department of Environment, Government of Newfoundland and Labrador, St. John's, NL.

Dempson, J.B., O'Connell, M.F., and Cochrane, N.M. 2001. Potential impact of climate warming on recreational fishing opportunities for Atlantic salmon, *Salmo salar* L., in Newfoundland, Canada. Fish. Manag. Ecol. 8: 69-82.

DFO. 2008. Stock Assessment of Newfoundland and Labrador Atlantic Salmon - 2007. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/055.

Elliott, J.M. 1981. Some aspects of thermal stress on freshwater teleosts. *In* Stress and Fish. Edited by A. D. Pickering. San Diego, California: Academic Press, pp. 209-245.

1991. Tolerance and resistance to thermal stress in juvenile Atlantic salmon, *Salmo salar* (L.). Freshw. Biol. 25: 61-70.

Elliott, J.M., and Chambers, S. 1996. A guide to the interpretation of sea trout scales. National Rivers Authority R&D Report 22. Bristol. ISBN 1 873160 29 1.

Gibson, R.J. 2002. The effects of fluvial processes and habitat heterogeneity on distribution, growth and densities of juvenile Atlantic salmon (*Salmo salar* L.), with consequence on abundance of the adult fish. Ecol. Freshw. Fish 11: 207-222.

Gibson, R.J., and Cunjak, R.A. 1986. An investigation of competitive interactions between brown trout (*Salmo trutta* L.) and juvenile Atlantic salmon (*Salmo salar* L.) in rivers of the Avalon Peninsula, Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci. 1472: v + 82 p.

Glahn, J.F., Harrel, J.B., and Vyles, C. 1998. The diet of wintering double-crested cormorants feeding at lakes in the southeastern United States. Colon. Waterbirds 21: 445-452.

Global Environmental Monitoring System. 2003. Salts and salinization of surface waters. 04-Mar-2009 <http://www.gemswater.org/atlas-gwq/salts-e.html>

Government of British Columbia. 2000. Ambient water quality guidelines for sulphate. 01 Jan 2008. <http://www.env.gov.bc.ca/wat/ wq/BCguidelines/ sulphate/ sulphate.html>

Granadeiro, J.P., Monteiro, L.R., Silva, M.C., and Furness, R.W. 2002. Diet of Common Terns in the Azores, Northeast Atlantic. Waterbirds 25: 149-155.

Hammell, M.O., and Stenson G.B. 2000. Estimated prey consumption by harp seals (*Phoca groenlandica*), hooded seals (*Cystophora cristata*), grey seals (*Halichoerus grypus*) and harbour seals (*Phoca vitulina*) in Atlantic Canada. J. Northwest Atl. Fish. Sci. 26: 1-23.

Hirsch, K. 1986. Colony expansion and food habits of double-crested cormorants in Minnesota. Pacific Seabird Group Bull. 13: 32-33.

Hobson, K.A., Knapton, R.W., and Lysack, W. 1989. Population, diet, and reproductive success of double-crested cormorants breeding on Lake Winnipegosis, Manitoba, in 1987. Colon. Waterbirds 12: 191-197.

Limburg, K.E., Landergren, P., Westin, L., Elfman, M., and Kristiansson, P. 2001. Flexible modes of anadromy in Baltic sea trout: making the most of marginal spawning streams. J. Fish. Biol. 59: 682-695.

Malvestuto, S.P., Daves, W.D., and Shelton, W.L. 1978. An evaluation of the roving creel survey with nonuniform probability sampling. Trans. Am. Fish. Soc. 107: 255-262.

Meisner, W. and Krupa, R. 2007. Biometrics and Primary molt of common tern and sandwich tern in autumn in Puck Bay, southern Baltic. Waterbirds 30: 158-163.

Mitchell, S.C., Scruton, D.A., Cunjak, R.A., and Gibson, R.J. 2005. Atlantic salmon and brook trout population and habitat characteristics of Northeast Brook, Trepassey,

Newfoundland and Labrador, 1984-96. Can. Tech. Rep. Fish. Aquat. Sci. 2569: ix + 73 p.

O'Connell, M.F. 1982. The biology of anadromous *Salvelinus fontinalis* (Mitchill, 1815) and *Salmo trutta* Linnaeus, 1758 in river systems flowing into Placentia Bay and St. Mary's Bay, Newfoundland. Thesis (Ph.D.) Memorial University of Newfoundland, St. John's, NL. 335 p.

O'Connell, M.F., Cochrane N.M., and Mullins, C.C. 1998. An analysis of the license stub return system in the Newfoundland region, 1994-97. DFO Can. Stock Assess. Sec. Res. Doc. 98/111. 67p.

O'Connell, M.F., Dempson, J.B., and Reddin, D.G. 2008. Inter-river, -annual and -seasonal variability in fecundity of Atlantic salmon, *Salmo salar* L., in rivers in Newfoundland and Labrador, Canada. Fish. Manage. Ecol. 15: 59-70.

ICES. 1984. Atlantic Salmon Scale Reading. Report of the Atlantic Salmon Scale Reading Workshop. Aberdeen, Scotland, 23-28 April 1984.

Ricker, W.E. 1975. Computation and interpretation of the biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 1-382.

Riley, S.C., Haedrich, R.L., and Gibson, R.J. 1993. Negative bias in removal estimates of Atlantic salmon parr relative to stream size. J. Freshw. Ecol. 8: 97-101.

Scruton, D.A. 1986. Spatial and temporal variability in the water chemistry of Atlantic Salmon Rivers in Insular Newfoundland: an assessment of sensitivity to and effects from acidification and implications for resident fish. Can. Tech. Rep. Fish. Aquat. Sci. 1451: v + 143 p.

Scruton, D.A., and Gibson, R.J. 1995. Quantitative electrofishing in Newfoundland and Labrador: result of workshops to review current methods and recommend standardization techniques. Can. Manuscr. Rep. Fish. Aquat. Sci. 2308: vii + 145 p.

Scruton, D.A., Anderson, T.A., Bourgeois, C.E., and O'Brien, J.P. 1992. Small stream surveys for public sponsored habitat improvement and enhancement projects. Can. Manuscr. Rep. Fish. Aquat. Sci. 2163: v + 49 p.

Scruton, D.A., Riley, S.C., Bennett, B.A., Bowdring, F.T., and Clarke, K.D. 2000. A review of habitat suitability criteria applicable to four salmonid species in Newfoundland, Canada. Can. Manuscr. Rep. Fish. Aquat. Sci. 2548: vi + 56 p.

Sjare, B., Lebeuf, M., and Veinott, G. 2005. Harbour seals in Newfoundland and Labrador: a preliminary summary of new data on aspects of biology, ecology, and contaminant profiles. DFO Can. Sci. Advis. Sec. Res. Doc. 2005/030.

Watt, W.D. 1981. Present and potential effects of acid precipitation on the Atlantic salmon in eastern Canada. *In* Acid Rain and Atlantic Salmon. Edited by L. Sochasky. IASF Spec. Pub. No 10. pp. 39-45.

Zippin, C. 1958. The removal method of population estimation. J. Wildlife Manag. 22: 82-90.

Table 1. Catch and effort data for Renews River Atlantic Salmon Recreational Fishery.

	Data from Guardians and Fisheries Officers				Data From License Stub Survey			
Year	Total catch	Rod days	CPU	Run Size based on 15% exploitation rate	Total catch	Rod days	CPU	Run size based on 15% exploitation rate
1965	50	17	2.94	333				
1966	34	100	0.34	227				
1967								
1968	22	169	0.13	147				
1969	12	16	0.75	80				
1970								
1971	34	283	0.12	227				
1972	28	280	0.1	187				
1973	97	404	0.24	647				
1974	49	490	0.1	327				
1975	84	442	0.19	560				
1976	75	375	0.2	500				
1977	77	385	0.2	513				
1978	38	190	0.2	253				
1979	91	260	0.35	607				
1980	114	243	0.47	760				
1981	71	296	0.24	473				
1982	90	429	0.21	600				
1983	43	358	0.12	287				
1984	73	304	0.24	487				
1985	96	533	0.18	640				
1986	131	624	0.21	873				
1987	36	225	0.16	240				
1988	79	439	0.18	527				
1989	95	297	0.32	633				
1990	78	300	0.26	520				
1991	11	220	0.05	73				
1992								
1993	52	400	0.13	347				
1994	52	193	0.27	347	31	289	0.11	207
1995	71	355	0.2	473	76	326	0.23	507
1996	59	536	0.11	393	77	369	0.21	513
1997	12	120	0.1	80	19	272	0.07	127
1998					46	277	0.17	307
1999					120	338	0.36	800
2000					71	480	0.15	473
2001					3	17	0.18	20
2002					68	286	0.24	453
2003					5	24	0.21	33
2004					13	62	0.21	87
2005					32	38	0.84	213
2006					113	227	0.50	753
2007					3	80	0.04	20

Table 2. Location and physical characteristics of the 2007 electrofishing sites.

Site #	Location	Area (sq m)	Rearing units	Average depth (cm)	Average velocity (cm/sec)	Habitat type	Total catch	Salmon	Brown trout	Fry	CPRU Total
100	N 46 56.123 W 52 57.266	185	1.85	18.1	20	Riffle	20	13	7	0	10.82
200	N 46 56.229 W52 57.368	329	3.29	22.9	34	Riffle	15	13	2	0	4.56
300	N46 56.358 W52 57.714	405	4.05	33.9	17	Riffle	15	15	0	0	3.70
400	N46 56.494 W 52 58.124	236	2.36	39.5	24	Riffle	7	7	0	0	2.97
500	N 46 56.530 W 52 58.290	289	2.89	22.9	25	Riffle	15	14	1	0	5.20
600	N 46 57.156 W 52 58.944	248	2.48	22.9	18	Flat	34	9	2	23	13.71
700	N46 57.290 W 52 59.143	277	2.77	21.6	16	Riffle	17	11	0	6	6.15

CPRU = Catch per rearing unit.

Table 3. Names and total number of observations of potential salmonid predators in Renews.

Common name	Species	Number of observations
Gulls	various species	1735
Common tern	*Sterna hirundo*	1542
Double crested cormorant	*Phalacrocorax auritus*	384
Harbour seals	Phoca vitulina	370
Kittiwake	*Rissa tridactyla*	135
Crow	*Corvus brachyrhynchos*	25
Greater yellowlegs	*Tringa melanoleuca*	22
Loon	*Gavia immer*	8
Kingfisher	*Ceryle alcyon*	1

Table 4. Temperature, pH, and salinity data for Inner Estuary samples below head of tide, and within Renews River samples

Inner estuary Sampling locations		Surface samples			Bottom samples		
		Temp °C	Salinity (ppt)	pH	Temp °C	Salinity (ppt)	pH
N 46 56.070	W 52 57.101	20.1	2.89	7.43	17.3	22.18	7.95
N 46 56.014	Data loss	19.7	3.34	7.60	16.6	26.15	8.01
N 46 55.987	W 52 57.155	19.4	2.49	7.50	17.7	18.90	7.67
N 46 56.018	W 52 57.154	19.6	4.34	7.40	18.3	15.08	7.72
N 46 56.025	W 52 57.163	20.5	2.94	7.45	18.9	19.18	7.70
N 46 56.031	W 52 57.160	20.0	2.05	7.61	17.5	22.67	7.84
N 46 56.064	W 52 57.139	19.6	3.81	7.39	18.6	16.44	7.81
N 46 56.052	W 52 57.077	19.6	3.63	7.91	16.5	26.94	8.05
N 46 56.069	W 52 57.046	19.0	12.15	7.80	16.1	27.65	8.24
N 46 56.024	W 52 57.088	18.0	22.67	7.99	16.9	26.22	8.08
Within river samples							
Sampling locations		Temp °C	Salinity (ppt)	pH			
N 46 56.087	W 52 57.215	23	0.01	7.07			
N 46 56.042	W 52 57.175	23.1	0.10	6.52			

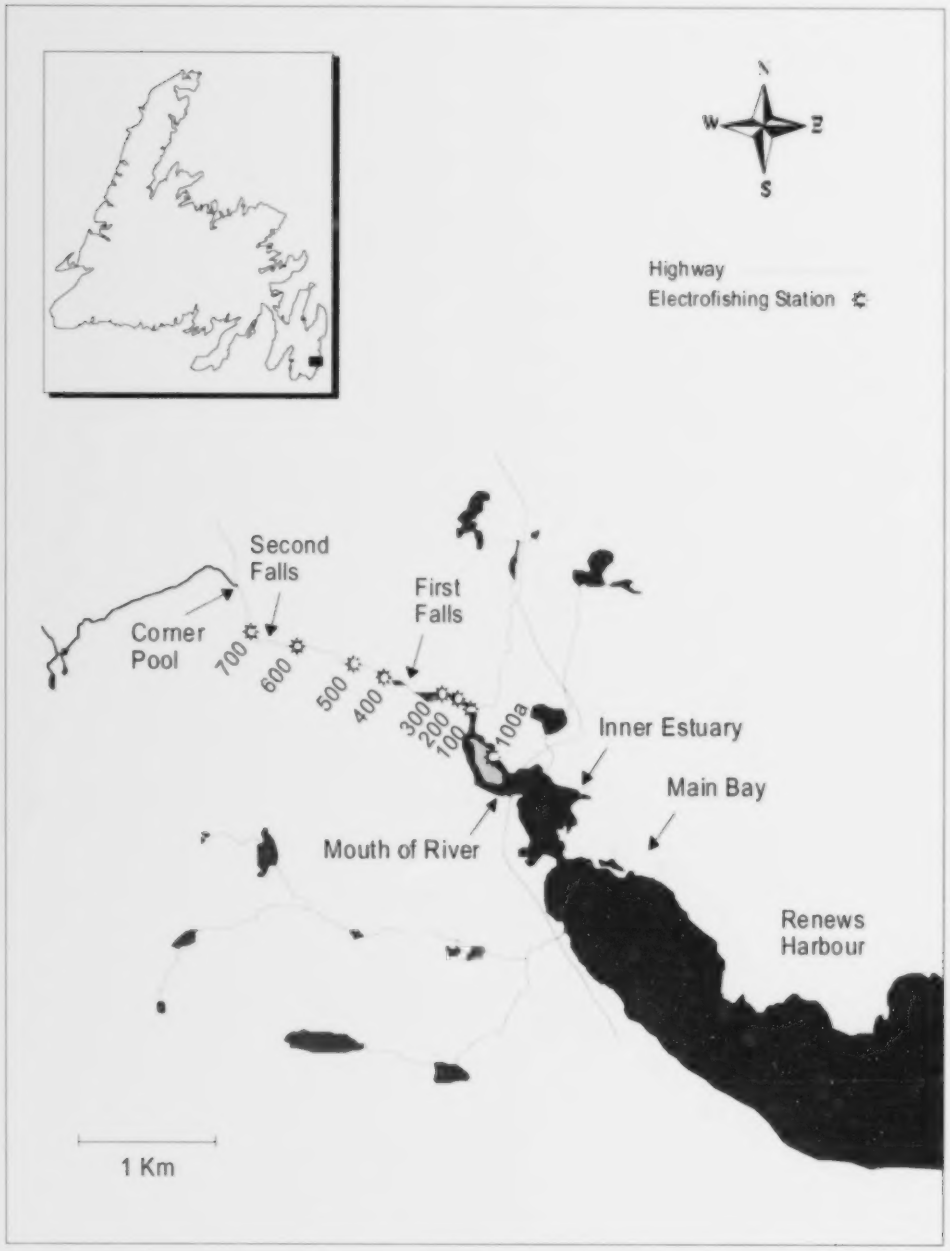


Figure 1. Map of lower section of Renews River watershed. Electrofishing sites are indicated by stars. Black square on insert identifies location of the Renews River watershed.

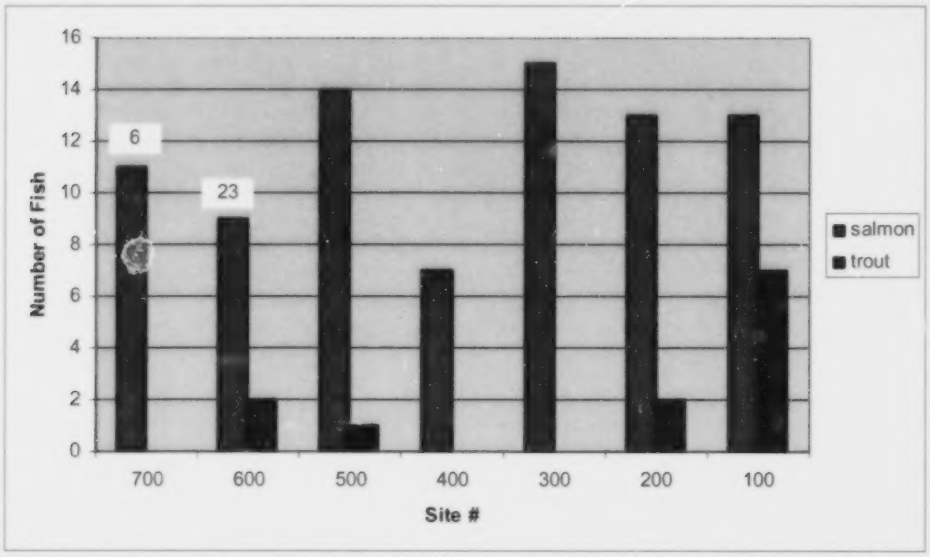


Figure 2. Results from the electrofishing survey. Sites are numbered in order from upstream (Site 700 is above Second Falls) to downstream (Site 100 is near the mouth of the river). Numbers above the bars are number of fry captured at each site.

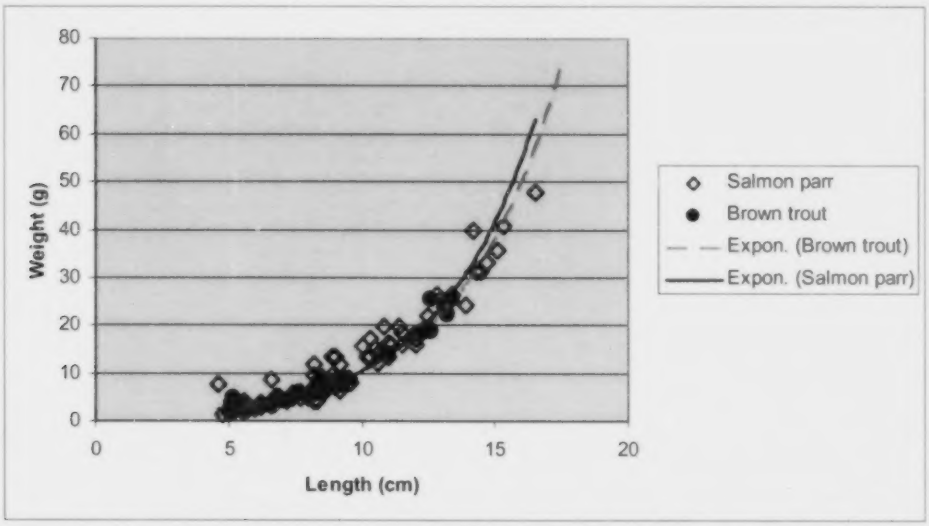


Figure 3. Length-weight relationship of Atlantic salmon and brown trout in Renews River.

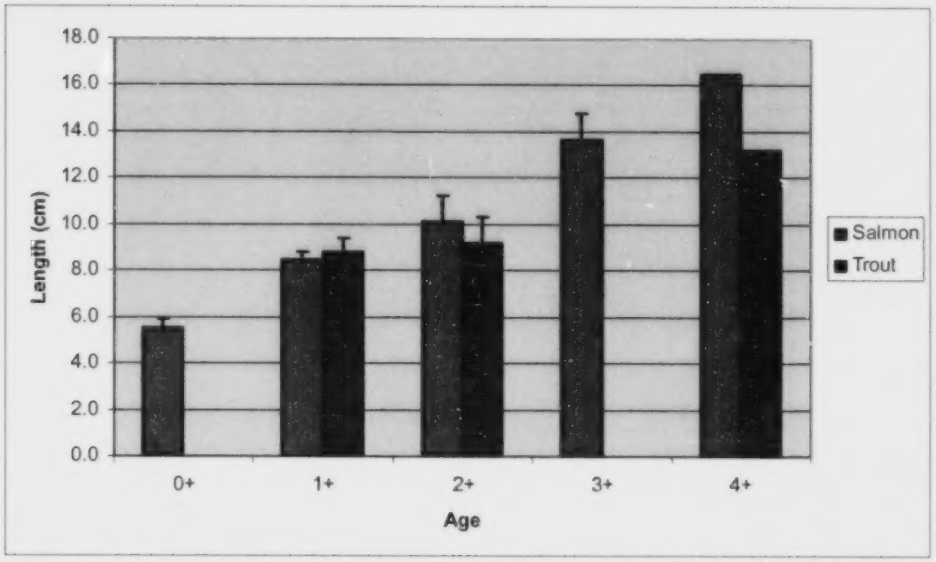


Figure 4. Age-length relationship for Atlantic salmon and brown trout samples from Renews River. Error bars represent 1 standard deviation. Age 4+ fish n=1.

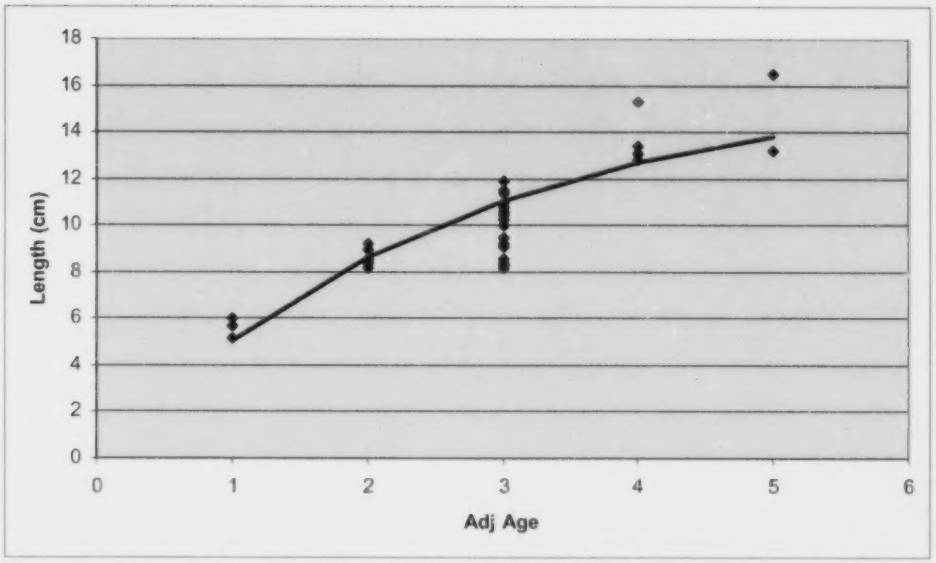


Figure 5. Age-length relationship for combined Atlantic salmon and brown trout from Renews River. Solid line is a fitted von Bertalanffy growth curve. Curve parameters are: L infinity = 16; K = 0.4; t_0 = 0.05.

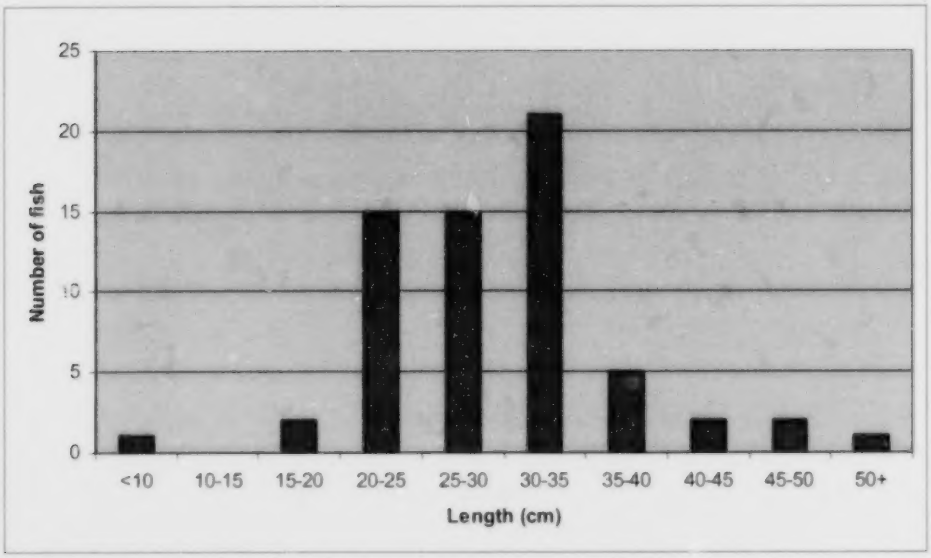


Figure 6. Size distribution of brown trout sampled in the recreational fishery at Renews.

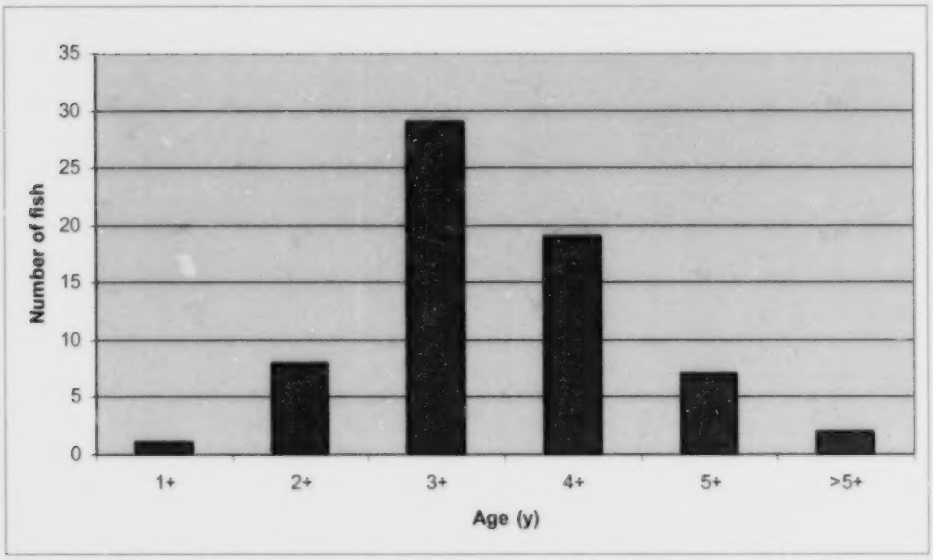


Figure 7. Age distribution of brown trout sampled in the recreational fishery at Renews.

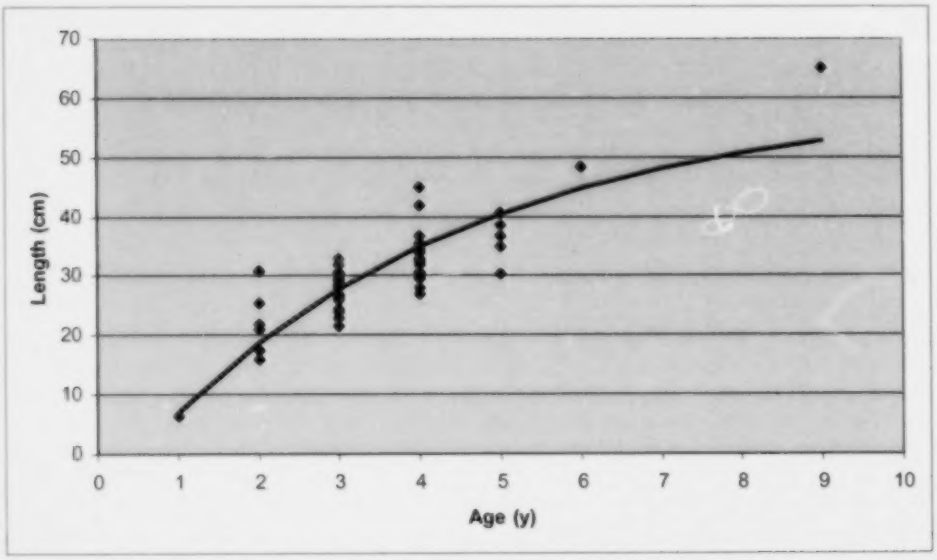


Figure 8. Age-length relationship for brown trout sampled in the recreational fishery at Renews. Solid line is a fitted von Bertalanffy growth curve. Curve parameters are: L infinity = 60; K = 0.25; t_0 = 0.5.

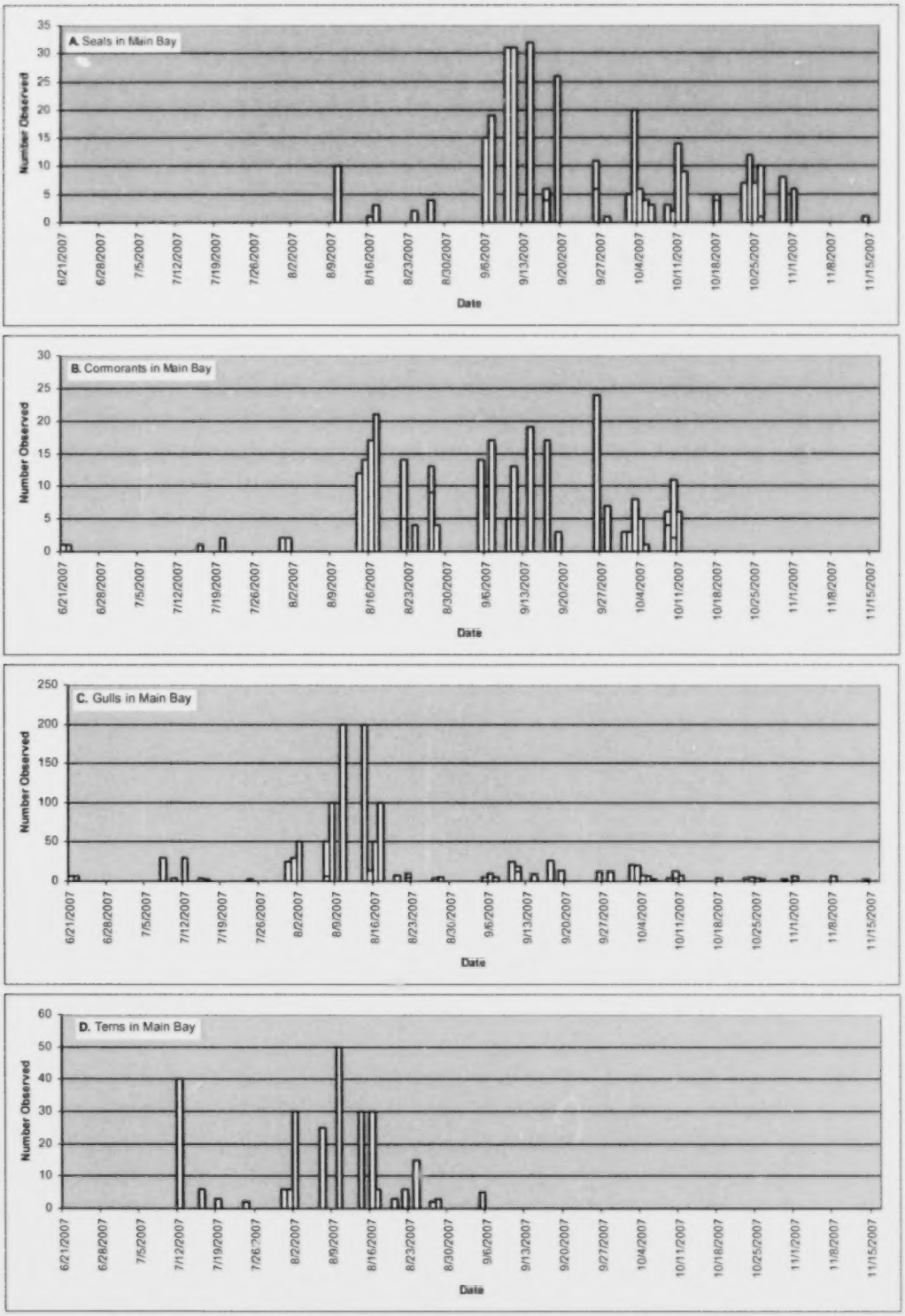
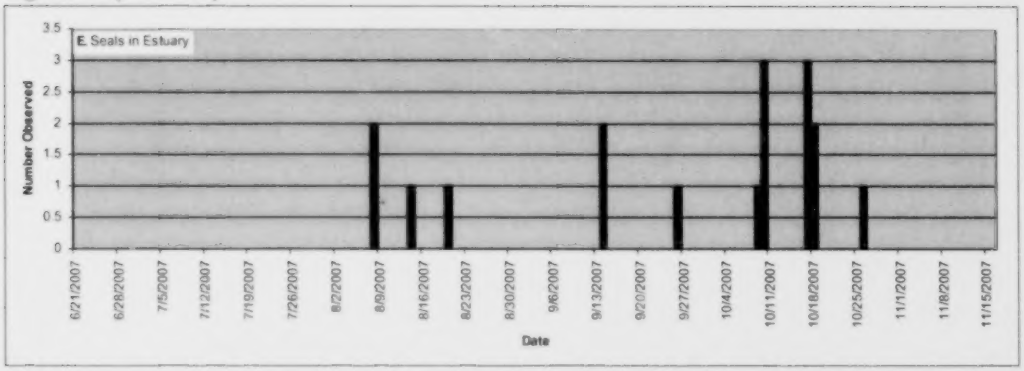
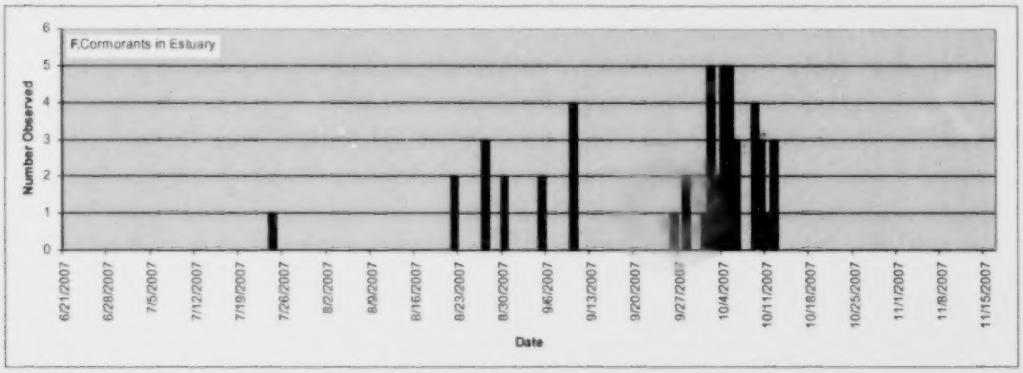
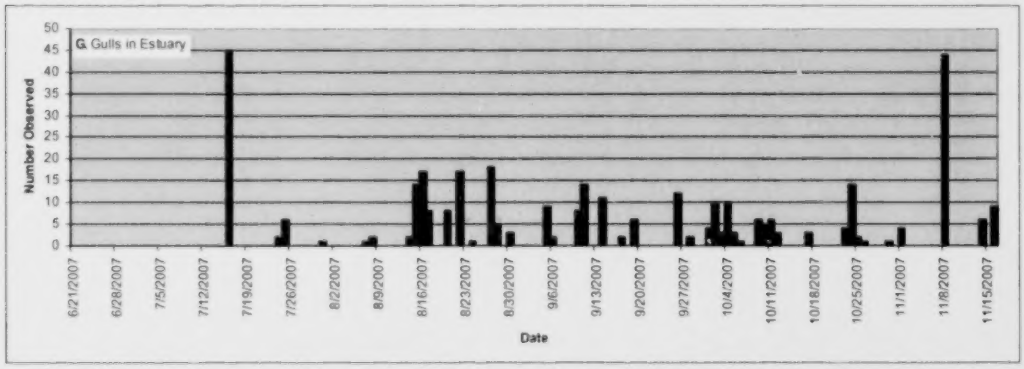


Figure 9. Observation date and abundance of the main salmonid predators in Renews.

Figure 9 (Cont'd.)







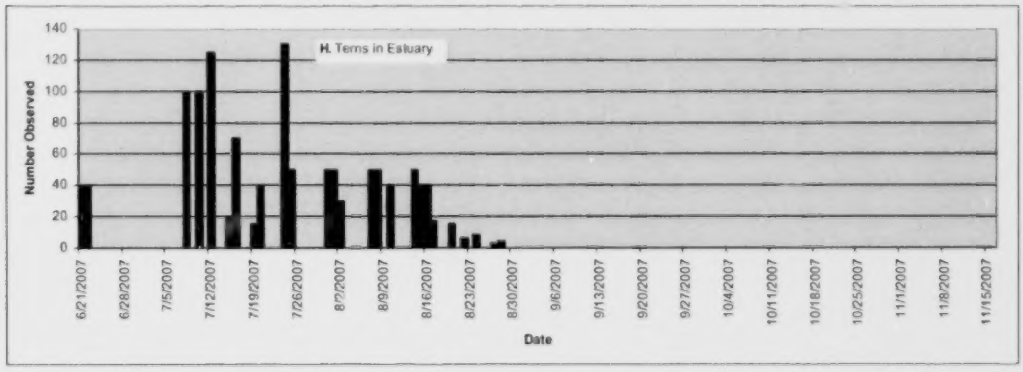
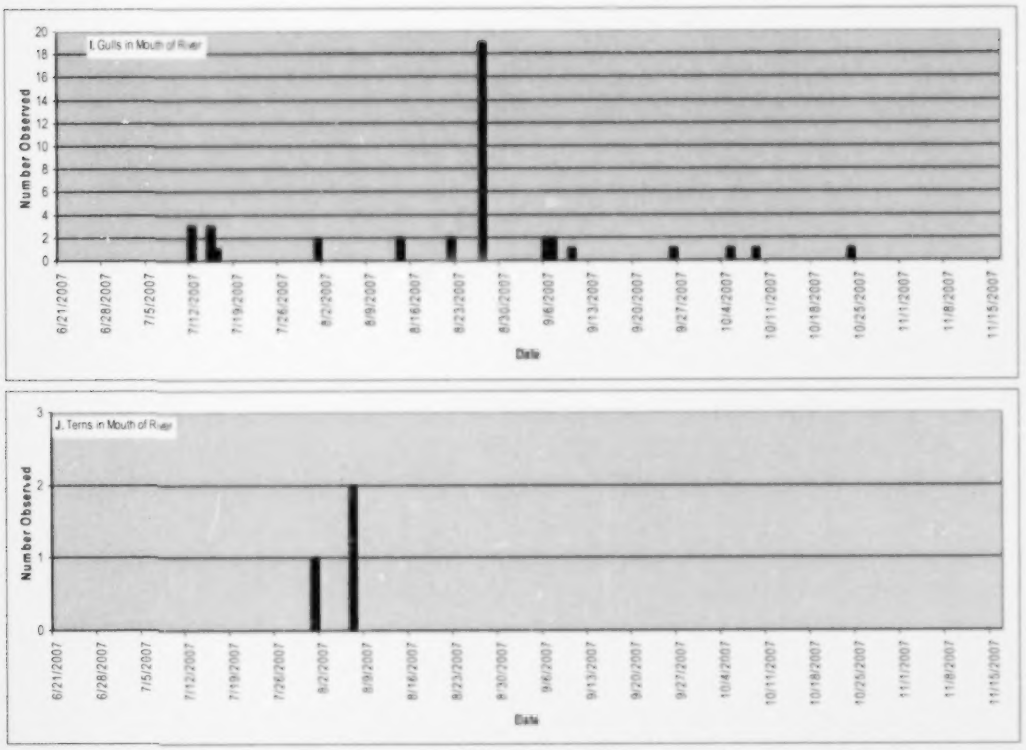


Figure 9 (Cont'd.)



Locations of Main Bay, Estuary, and Mouth of River are shown on Figure 1.

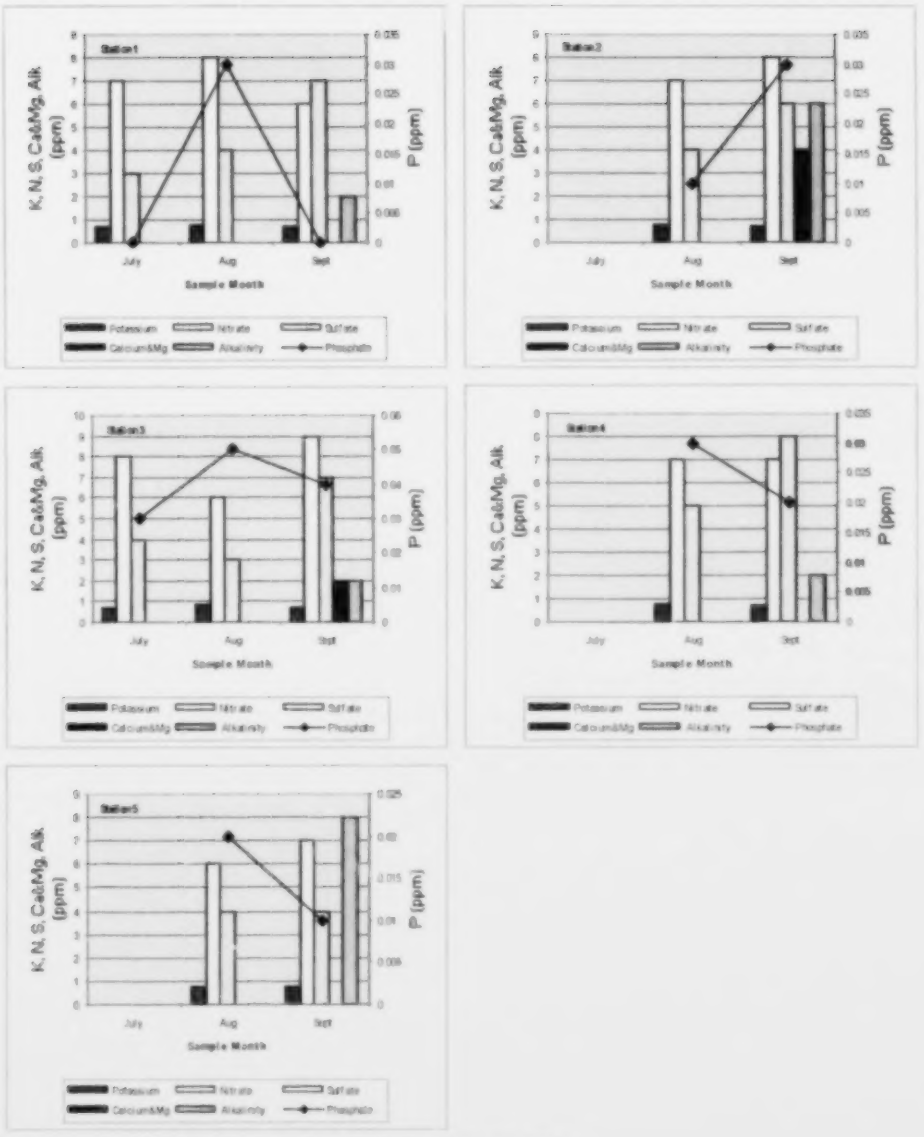


Figure 10. Water quality data for Renews River.

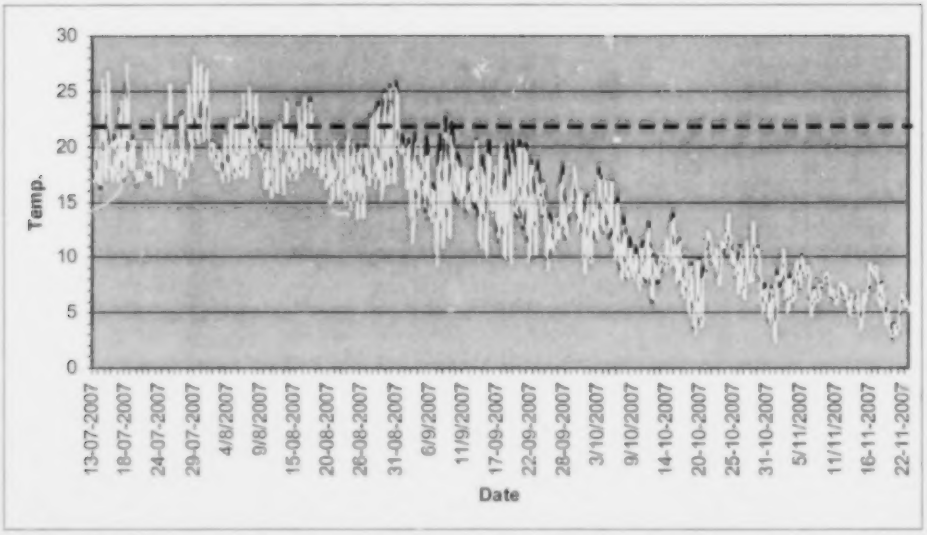


Figure 11. Renews River thermograph data for three stations. Lines of the individual stations are not distinguishable except where they do not overlap. Dashed line indicates 22 °C.